

# Coronal Loop Evolution Observed with AIA and Hi-C

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## Abstract

Despite much progress toward understanding the dynamics of the solar corona, the physical properties of coronal loops are not yet fully understood. Recent investigations and observations from different instruments have yielded contradictory results about the true physical properties of coronal loops. In the past, the evolution of loops has been used to infer the loop substructure. With the recent launch of High Resolution Coronal Imager (Hi-C), this inference can be validated. In this poster we discuss the first results of loop analysis comparing AIA and Hi-C data. We find signatures of cooling in a pixel selected along a loop structure in the AIA multi-filter observations. However, unlike previous studies, we find that the cooling time is much longer than the draining time. This is inconsistent with previous cooling models.

## Background

- If the loop is a single, cooling strand, there exists a relationship between the delay between the two filters and the lifetime of the loop in a single filter (see Winebarger et al. 2003 or Mulu-Moore et al. 2011 for more details).
- The delay is simply the difference in appearance times between two filters and the lifetime is the difference between the appearance and disappearance of a loop in a single filter.
- In the TRACE instrument the cooling time can be estimated from the measured delay as

$$\gamma_T \sim 3.1 (\Delta t_{195-171}).$$

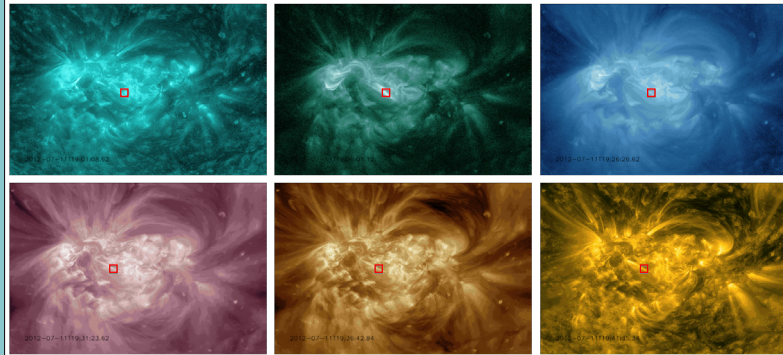
- The expected lifetime can then be calculated from the measured cooling time, i.e.

$$T_{195\text{calc}} \sim 0.49 \gamma_T,$$

and compared to the observed lifetime. If the expected and observed lifetimes agree, the loop can be modeled as a single cooling strand at an isothermal temperature. If not, the loop must be multiple strands, each at different temperatures.

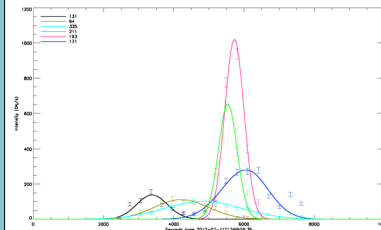
- Using AIA instrument's corrected response functions, we can derive similar relationship between the delay, cooling time and lifetime of coronal loops. We are now able to further infer and validate this relationship using loops observed by Hi-C at the best spatial resolution ever.

## AIA Multi-filter Observation

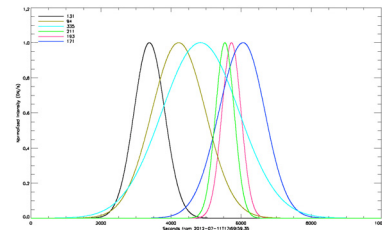


**Figure 1.** AIA multi-filter observation of AR1520 observed on 11-July-2012 is shown in 131 Å, 94 Å, 335 Å, 211 Å, 193 Å and 171 Å respectively. The red box shows the location of the selected pixel. The intensity of the loop structure appears to peak in the 131 Å filter image at 19:01 UT, in the 94 Å filter image at 19:06 UT, in the 335 Å filter image at 19:26 UT, in the 211 Å filter image at 19:31 UT, in the 193 Å filter image at 19:36 UT and at 19:41 UT in the 171 Å filter image. As this structure cools, it becomes less "fuzzy" and two identifiable structures form.

- The calculated intensity of the loop structure as a function of time in the selected pixel is shown in Figures 2. The normalized intensities are shown in Figure 3. The light curves in the figures show the temporal evolution of the structure. As the loop structure cools, it appears in the "hotter" AIA filter images before appearing in the "cooler" filters images.
- Typically, plasma is parameterized by a cooling time,  $\gamma_T$ , or the characteristic time over which the plasma's temperature decreases. In Figure 4 (top), the temperature profile of the AIA channels at the peak time of their responses is shown. From that temperature profile, we have calculated a cooling time as the structure cools from the 211 to 171 AIA filters.



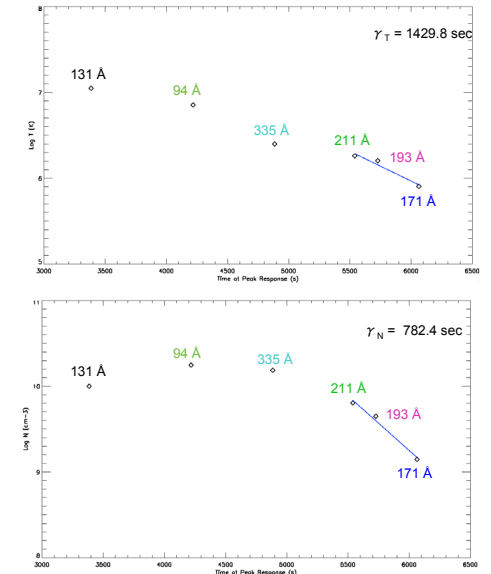
**Figure 2.** Intensity of loop at one pixel in the six AIA channels as a function of time. The solid lines are a symmetric/asymmetric Gaussian fits to each light curve.



**Figure 3.** Normalized Intensity of loop at one pixel in the six AIA channels as a function of time. The solid lines are a symmetric/asymmetric Gaussian fits to each light curve.

- Similarly, we can estimate a draining time ( $\gamma_N$ ) from the density profile shown in the bottom panel of Figure 4. To calculate the density of the observed loop structure, we used the AIA temperature response for all the filters used, the observed intensities, a filling factor of 1 and a volume. The bottom panel of Figure 4, shows the calculated densities as a function of time at the peak of the filter responses.

- The best approximation of the draining time is obtained when most of the heating in the loop structure has ceased (for example, as the plasma drains from the 211 filter to the 171 AIA filter). We calculate the draining time to be 782 seconds.
- Unlike what previous models have shown, in this observation, plasma in the loop structures drains almost twice as fast as it cools.



**Figure 4.** The temperatures as a function of time at the peak of the AIA response for all the AIA filters is shown (top). The cooling time ( $\gamma_T$ ) calculated as the negative inverse of the slope of the line (shown in blue) is 1429.8 seconds.

## Acknowledgment

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